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LABORATORY DIRECTIONS
FOR
GENERAL BIOLOGY

LORANDE LOSS WOODRUFF
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New Haven
Osborn Zoological Laboratory
Yale University
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Annex

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I am impressed with the fact that the greatest thing a human soul ever does in the world is to see something, and tell what it saw in a plain way. Hundreds of people can talk for one who can think, but thousands can think for one who can see.

Emerson.

The invention of the microscope made small things seem large, and revealed to sight what was too small to be seen without it; but the use of magnifying glasses brought an advantage with it of a different kind—it taught those who used them to see scientifically and exactly. In arming the eye with these increased powers the attention was concentrated on definite points in the object; what was seen was to some extent indistinct, and always only a small part of the whole object; perception by means of the optic nerve had to be accompanied by conscious and intense reflection, in order to make the object, which is observed in part only with the magnifying glass, clear to the mental eye in all the relations of the parts to one another and to the whole. Thus the eye armed with the microscope became itself a scientific instrument, which no longer hurried lightly over the subject, but was subjected to severe discipline by the mind of the observer and kept to methodical work. The philosopher Christian Wolff observed very truly in 1721, that an object once seen with the microscope can often be distinguished afterwards with the naked eye; and this, which is the experience of every microscopist, is sufficient evidence of the effect of the instrument in educating and training the eye.

Sachs.

EQUIPMENT.

1. Each student will require the following equipment for his laboratory work:

(a) Provided by the student:

1. Text-books.
2. Loose-leaf notebook, about $8\frac{1}{2} \times 10\frac{3}{4}$ inches, with white drawing paper.
3. Dissecting instruments in case, consisting of scalpel, scissors, small forceps, two needles in holders and ruler.
4. Two pencils for drawing—3H and 6H.

(b) Provided by the laboratory:

1. Compound microscope with two eyepieces and two objectives.
2. Dissecting microscope with one lens.
3. Six glass slides.
4. Ten cover glasses.
5. Lens paper for cleaning lenses of microscopes.
6. Filter paper.
7. Cloth for cleaning slides and cover glasses.
8. Pins.

Each student on being assigned a seat in the laboratory should check the list of equipment as given above and see that it is complete.

USE AND CARE OF THE MICROSCOPE.

1. The compound microscope is a delicate, complicated, and expensive instrument and must always be handled with great care. It consists of the following parts:

- (a) The **base and upright support**.
- (b) The **stage** with a **central opening** which contains an **iris diaphragm** for regulating the amount of light.
- (c) The **mirror**, with concave and plane surfaces, which is attached underneath the stage.
- (d) The **body**, with **coarse and fine adjustments** for focusing, **draw tube**, **eyepiece**, and revolving **nosepiece** holding two **objectives**.

Identify each of these parts and learn how they are used.

2. Each day before using the microscope, see that all parts are clean. Be sure that they are kept clean during the exercise and that the instrument is clean when you leave. If you find the instrument dirty or in bad order, report it at once to the assistant in charge of the room. Lens paper is furnished for cleaning the lenses and it is not permissible under any circumstances to touch the lenses with any other material.

3. Place the microscope in position, with the upright support towards you. See that eyepiece 1 and objective 3 are in position and that the iris diaphragm is open. Adjust the mirror so that the maximum amount of light will be reflected up through the central opening of the stage. In general, use the mirror with the concave surface up.

4. Place the slide, on which the object to be examined is mounted, upon the stage with the object directly over the central opening. Carefully turn the coarse adjustment screw away from you until the tip of the objective is approximately one-fourth of an inch from the upper surface of the slide. Then, while looking through the eyepiece, slowly turn the coarse adjustment screw towards you until the object comes into view. Bring the image into an exact focus by slowly turning the fine adjustment screw either to the right or left, as may be necessary. Never focus downwards with the coarse adjustment while looking through the microscope.

USE AND CARE OF THE MICROSCOPE (Continued).

5. Always find an object first with the lowest power (eyepiece 1 and objective 3) as described in the preceding paragraph. Before changing from a lower to a higher power, always see that the object is exactly in the center of the field. The magnification may then be increased as desired in the following ways:

- (a) By replacing eyepiece 1 with eyepiece 3.
- (b) By replacing objective 3 with objective 7. This is accomplished by revolving the nosepiece. Inasmuch as objective 7 comes to a focus very close to the upper surface of the preparation, it will be necessary to use great care in making this change.
- (c) By doing both (a) and (b).

The approximate magnifications afforded by the various combinations are as follows:

Eyepiece 1 × objective 3 = 50 diameters magnification.					
"	3 ×	"	3 = 80	"	"
"	1 ×	"	7 = 300	"	"
"	3 ×	"	7 = 500	"	"

The magnification can be still further increased by extending the draw tube, but this method is rarely used.

When a lower magnification is desired the **dissecting microscope** is used. It gives a magnification of about 10 diameters.

Always use the lowest magnification possible to accomplish the work in hand.

6. At the close of each exercise, be sure to remove, from the stage of the microscope, the slide that you have been studying. Examine the microscope carefully and make sure that all parts, including the lenses, are perfectly clean, and then return the microscope to its case.

Remember that since there are others who must use the same microscope, the welfare of the laboratory depends upon your cooperation in keeping the apparatus in order.

MICROSCOPIC PREPARATIONS.

7. The objects which will be examined with the compound microscope may be divided into two classes, as follows:

(a) **Permanent mounts**, in which the object to be examined has been previously subjected to complicated histological methods of preparation. Great care must be observed in handling these preparations. A charge will be made for breakage.

(b) **Temporary mounts**, which you will make from time to time from fresh materials according to the following directions:

1. Thoroughly clean a glass slide and cover glass.
2. Place a small drop of water in the center of a glass slide.
3. Place the object to be examined in the drop of water.
4. Cover the drop of water containing the object with a cover glass.
5. Remove any superfluous water remaining around the cover glass with filter paper. Be sure that no water gets onto the upper surface of the cover glass. The preparation is now ready to be studied under the microscope.

LABORATORY DRAWINGS.

8. It is essential that careful attention be paid to the following rules for laboratory drawings:

- (a) Always **label** every drawing and each of its parts.
- (b) Arrange the drawings as neatly and evenly on the page as possible, giving each plenty of space.
- (c) Leave at least an inch margin around the edges of the sheet.
- (d) Draw only on one side of the paper.
- (e) Remember particularly that accuracy and neatness are two of the most important factors in good laboratory work.
- (f) See that the laboratory room number, the seat number and your name and class is placed on the upper right hand corner of each sheet of drawings.

PRELIMINARY MICROSCOPIC WORK.

A. Dissecting Microscope.

1. Examine, with the dissecting microscope, a slide on which the printed word YALE has been permanently mounted.
2. Make an outline drawing of the word Yale in its apparent position and magnification.
3. What apparent movement results when the slide is moved to the right? To the left? When it is moved toward and away from you? When it is rotated?

B. Compound Microscope.

4. Examine, with the lowest power (eyepiece 1 and objective 3) of the compound microscope, the letter L from the same preparation you have been studying. Draw this letter in its apparent position and magnification.
5. What apparent movement results when the slide is moved to the right? To the left? When it is moved toward and away from you? When it is rotated?
6. Replace eyepiece 1 with eyepiece 3. Draw.
7. Replace eyepiece 3 with eyepiece 1 and, by revolving the nosepiece, replace objective 3 with objective 7. Carefully refocus with fine adjustment. Draw.
8. Replace eyepiece 1 with eyepiece 3. Draw.
9. Note that the magnification can be still further increased by extending the draw tube. Extend it to its full length and, after refocusing, note the effect on the magnification.
10. Examine (eyepiece 1 and objective 7) a preparation of scales from the wing of a butterfly. Make several outline drawings showing different types of scales.
11. Replace eyepiece 1 with eyepiece 3. Study the markings on the surface of the scales and make a drawing of a small portion of a scale to show their character.

PLANT STRUCTURE.

1. Carefully peel off with a scalpel a portion of the delicate transparent covering (**epidermis**) from the upper surface of the leaf provided. Place in a drop of water on a slide. Cover and examine with the low power of the microscope.

2. Make a drawing of about ten adjacent **epidermal cells** to show the shape and arrangement, making each cell about half an inch in diameter.

3. Examine, with the low power, a prepared slide of stained sections of **onion root**. Note that some of the sections are cut transversely, and that others are cut longitudinally.

4. Study a transverse section. Note the faintly stained granular substance (**cytoplasm**) which surrounds the **nucleus** of each cell and fills the greater part of the space within the cell wall. Note the **vacuole**.

5. Draw, under the high power, about 10 adjacent cells which show the **nuclei**, making each cell about half an inch in diameter.

6. Draw a single cell about an inch in diameter showing **cell wall, cytoplasm, nucleus, and vacuole**.

7. Make a similar drawing of a cell from near the tip of a longitudinal section.

8. Compare the drawings of the cell (6 and 7). You have shown the three dimensions of the cell. Now make an outline in perspective of a single cell, about an inch in diameter.

ANIMAL STRUCTURE.

1. With the handle of a scalpel gently scrape the inside of your cheek. Mount the scrapings on a clean slide in a drop of water, cover with a cover glass and study with the high power. Note the shape of the cells.

2. Draw several cells of different shapes.

3. Add a drop of acetic carmine, and note the changes which take place. The central body, which takes a deeper stain, is the **nucleus**.

4. Make a drawing about an inch in diameter of a single cell, showing the appearance of **cytoplasm** and **nucleus**.

5. Examine in a drop of eosin-water a small piece of the shed skin (**epidermis**) of the frog. Study with the high power and draw about 10 adjacent cells.

6. Examine a stained and mounted section of the liver of some animal and draw several of the cells as seen under high power.

7. Mount a drop of frog's blood under the cover glass. The cells float in a lifeless plasma. Note their appearance under the low power.

8. Examine, with the high power, gently tapping the cover glass from time to time in order to set the red cells in motion so that you may see their three dimensions. Draw three or four cells as seen from various aspects.

AMOEBA.

1. Examine, with the high power, a drop of water which contains amoebae. These will be noted as very small, irregular, semi-transparent, granular bodies. When one is found, be careful not to move the slide so as to lose the specimen. Note: (1) the method by which the animal moves, (2) the constant but slow changes in the shape of the body and (3) the irregular processes (**pseudopodia**) which are formed.

2. Distinguish the transparent outer layer of protoplasm (**ectoplasm**) from the inner granular mass (**endoplasm**). Examine particularly the pseudopodia in this connection.

3. Make at least 10 outline drawings at 1 minute intervals showing changes in the shape of the organism. Indicate in each drawing the anterior and posterior end.

4. Note the food materials in process of digestion. They are contained in **food vacuoles**. If carefully watched it is sometimes possible to observe the manner in which amoeba ingests food and discharges the indigestible refuse.

5. Make out the transparent, spherical **contracile vacuole**. Note that the fluid contents are discharged at intervals. Find the **nucleus**.

6. Make a drawing (2 or 3 inches in diameter) of an animal to show the above mentioned details of structure.



PROTOPLASMIC MOVEMENT.

1. Place a leaf of *Elodea* in water under a cover glass and examine with low power. Sketch a small part of the leaf to show the arrangement of cells.

2. Examine with the high power, and find a cell which shows a movement of its contents. Carefully study the nature of the movement. Does the substance move in the same direction in all the cells? Does it change its direction after a time? Do any of the green bodies (**chloroplastids**) pass through the walls between adjacent cells? What is their course? Draw several adjacent cells and indicate the direction of movement by arrows.

3. Treat with iodine solution. Make a large drawing of a cell to show **cell wall, cytoplasm, nucleus, chloroplastids and vacuole.**

4. Examine a few filaments of *Oscillatoria* under the high power, and make a diagram to illustrate the nature of the movement observed.

5. Observe the movements shown on stimulation of the Sensitive Plant (*Mimosa*).

6. Place a small piece of a **gill of a clam** on a slide and with two needles tease it apart gently in a drop of the body fluid. Cover and examine with high power. Note the currents in the surrounding fluid caused by the **ciliated cells** of the gill. These cells are covered on one side with delicate, protoplasmic processes (**cilia**) which are in rapid vibration.

7. To demonstrate the fact that lifeless particles may also exhibit motion, examine, with the high power, a drop of water containing a little powdered carmine. The motion observed is termed "**Brownian movement.**"

SPIROGYRA.

1. Place a few filaments of the living plant in water on a slide, cover and examine with low power. Draw a small portion of one of the filaments showing its division into cells.

2. Examine with high power. Note the cell walls and the connection between adjacent cells. Note also in each cell the long, band-like, green **chloroplastids**. Count them and make out their arrangement. Make a drawing about two inches in length of a single cell, showing the chloroplastids and the connection with adjacent cells.

3. Treat the preparation with iodine solution. Note the changes of color in the rounded bodies imbedded in the chloroplastids. These are reserve food bodies (**pyrenoids**), and their blue color after treatment with iodine indicates the presence of starch.

4. Examine the cell wall carefully and note the thin layer of **cytoplasm** which lines it internally, and the large **vacuole** filled with cell sap, which occupies the greater part of the cell. Focus carefully near the center of the cell and find the **nucleus**, surrounded by a thin layer of the cytoplasm.

5. Add all of these parts to your drawing.

6. **Asexual reproduction:**—Examine a number of filaments carefully to see whether there is evidence of recent multiplication by transverse division of some of the cells. Draw.

7. **Sexual reproduction:**—Examine, with low power, a stained and mounted preparation which shows two filaments in process of **conjugation**. Study with high power and draw as many stages in the process of conjugation as can be found, including the fully formed **zygotes**.

YEAST.

1. Examine a flask of water in which has been placed some compressed yeast and sugar. Note the physical character of the fluid, including the smell, color and taste. Note the minute bubbles of gas (carbon dioxide) which are continually rising to the surface.

2. Place a drop of the scum on a slide, cover and examine with the low power. Note the **yeast cells** and the starch grains interspersed among them. Examine both of these under the high power and draw.

3. Make a series of sketches to show the **multiplication** of yeast cells by **budding**. Draw a large **cell colony**. How many cells are there in a yeast plant?

4. Treat with iodine solution. The starch grains are stained a deep blue and the yeast cells, brown. Make a large drawing to show the **structure** of the yeast cell, indicating **cell wall, cytoplasm, vacuole and oil globules**. The nuclear material cannot be distinguished except by special staining.

BACTERIA.

1. Examine, with the highest power, the different forms of Bacteria which occur in a drop of stagnant water. The very long filamentous forms filled with minute sulphur granules are **Beggiatoa**. The rod-like forms are **Bacilli**. The extremely minute dot-like forms are **Micrococci**. The corkscrew-like forms are **Spirilla**. Note the movements which each kind of Bacteria exhibits. Compare with "Brownian movement." Make a drawing of each kind of Bacteria observed.

2. Examine in a drop of water on a slide a little of the substance found between your teeth. Make a drawing of each kind of Bacterium found.

3. Examine a drop of water in which a piece of meat has been decomposing. Make drawings.

4. Examine the series of stained preparations of various Bacteria, and sketch a few cells of each.

MOLD.

1. Examine the fungus growth on a piece of moldy bread and note its general appearance.

2. With needles, tease apart a minute piece of bread bearing the mold in a drop of water on a slide, cover and examine with the low power. Each of the filaments of the fungus is known as a **hypha**; the hyphae comprise the **mycelium**, or vegetative portion of the fungus.

3. Determine the shape of a hypha. Find the following forms of hyphae: (a) the relatively **thick filaments** which ramify through the substance of the bread; (b) the groups of **short, root-like hyphae**; (c) the **erect hyphae**, each bearing at its apex a **sporangium** with **spores**. Draw a portion of the plant which shows all these parts.

4. Make four drawings of **sporangia** in different stages of development, ending with the stage at which the spores have been discharged. Draw also a few of the **spores**.

MOSS.

1. In this plant the sexual generation (**gametophyte**) is the green, leafy, independent moss plant. It consists of an upright stem bearing leaves, which are arranged in spirals, and root-like structures (**rhizoids**).

2. The asexual generation (**sporophyte**) is a dependent structure which develops from the tip of the gametophyte and remains attached to it. It consists of a **foot, stalk and capsule**.

3. Examine a specimen of the gametophyte of the moss plant which has a sporophyte attached to it. Note the parts mentioned above and make a drawing to show the structures observed.

4. Open the capsule of the sporophyte and note that it contains minute brown bodies which are the **spores**. Mount a few of these in a drop of water on a slide. Study their structure under the microscope and make a drawing of two or three of them.

5. Study, with the low power, a prepared slide on which has been mounted the tip of a gametophyte to show the sexual organs situated there. Note: (1) the larger club-shaped male organs (**antheridia**) which contain great numbers of **sperm cells**; (2) the slender female organs (**archegonia**) with enlarged basal portions, each of which contains a single **egg cell**; (3) the numerous rod-like structures (**sterile hairs**) which are found interspersed among the sexual organs. Make a drawing to show structures observed.

FERN.

1. In this plant the sexual generation (**gametophyte**) consists of a small green independent leaf-like structure known as a **prothallium**.

2. The asexual generation (**sporophyte**) is the large, leafy fern plant, and it shows a differentiation into **root**, **stem** and **leaf**.

Asexual.

3. The stem of the fern sporophyte (**rhizome**) grows underground. It bears the leaves which grow upward and the roots which grow downward. The portion of the plant above ground consists of the leaf stalk (**stipe**) and the leaf proper (**lamina**). Each leaf is subdivided into a number of lobes (**pinnae**) and these are further subdivided in some species into leaflets (**pinnules**).

4. Examine the leaves and note that they are of two kinds: (1) sterile leaves (**foliage**) and (2) fertile leaves (**sporophylls**) on the under surface of which the spores are developed in the raised bodies (**sori**). The sori are covered over by flap-like outgrowths (**indusia**) of the surface of leaf.

5. Make a drawing of the upper surface of a foliage pinna to show the **venation**, and also of the under surface of a sporophyll to show the sori.

6. Scrape off a few of the sori and place them in a drop of water on a slide. Tease them apart with dissecting needles and examine under low power. Note that they contain numerous spore cases (**sporangia**) which are filled with the minute brown **spores**. Note also the manner in which the sporangia open to discharge the spores. Make a drawing to show the structures observed.

Sexual.

7. Mount a Prothallium in a drop of water on a slide. Examine it first with a dissecting microscope and then with a compound microscope.

8. Study the plant from the under surface and note: (1) the root-like structures (**rhizoids**) by which it is attached to the soil; (2) the male sexual organs (**antheridia**) which occur near the base among the rhizoids; (3) the female sexual organs (**archegonia**) which occur near the **apical notch** at the anterior end. Make a drawing of the under surface showing the structures observed.

9. Examine a preparation which shows the manner in which the young sporophyte develops from the archegonium of the prothallium after fertilization has occurred.

SEED AND SEEDLING.

1. Remove the **seed coats** of a bean seed which has been soaked in water, and sketch the **embryo** of this dicotyledonous seed with the two thick seed leaves (**cotyledons**).

2. Separate the cotyledons carefully, lay them on their sides, and sketch the parts in this position; showing the **cotyledons**, **hypocotyl**, and the small bud, (**plumule**) with its two folded leaves.

3. Draw a seed which is just commencing to germinate, and a series of seedlings between one and three weeks old. Show the changes in position, shape and color of the cotyledons; the development of the primary root and its branches (**root system**); and the development of the epicotyl into nodes internodes and leaves (**shoot system**).

4. Make a similar study and drawings of the seedlings of the corn, which represents the monocotyledonous type.

ROOT.

1. Place the root of a small radish seedling on a slide with a little water. Cover and examine with the low power. Study and make a drawing of the tip of the root showing the **root hairs, growing point and root cap.**

2. Select a favorable portion of the field and focus directly on the root hairs. Draw a few of them to show their structure as observed. Stain the preparation with a little iodine. This should bring out the cytoplasm and nuclei of the cells. If found, add these to your drawing.

3. Study a transverse section of a young corn root. Draw to show the general structure of the root, emphasizing particularly the cellular structure of the root hairs.

STEM.

1. Examine, with the low power, a prepared transverse section of the stem of an herbaceous plant (e.g., *Aristolochia*) and draw a quadrant of the section to show the arrangement of the various tissues. Note: **epidermis, cortex, vascular bundles with cambium cells and parenchyma.**

2. Study a vascular bundle under the low power. Make an enlarged drawing to show the structural arrangement of the **xylem, phloem and cambium tissues.**

3. Draw, under low power, a quadrant of a transverse section of the stem of a young pine to show the **bark, cambium ring, rings of annual growth, medullary rays, resin ducts and pith.**

4. Study the three cut surfaces of the stem of an oak. Make a drawing showing the relations of the parts listed in the above question.

BUD.

1. Examine, with the low power, a stained and mounted median longitudinal section of the typical **naked bud** of Elodea. Note that it consists of (1) the central stalk (**rudimentary stem**) and branching off from it (2) the **rudimentary leaves** and **branches** in various stages of development. The diameter of the rudimentary stem is larger in the older portions of the bud and it gradually decreases until it terminates in (3) the **growing point**.

2. Note that the leaves develop in regular order, the youngest leaves being nearest the growing point. In the early stage they consist of only a few cells and form small mounds on the surface of the stem. The older leaves overarch the growing point and form a protection for it. Make a drawing to show all structures observed.

3. Examine, with the naked eye and also with the dissecting microscope, the typical **scaly bud** of the Lilac. It consists of the same parts as the naked bud, but, for protection during the winter, the outer leaves of the bud (**scale leaves**) are differentiated from the inner leaves (**foliage leaves**). Make a slightly enlarged drawing of the bud to show the external structure. Label.

4. Remove the leaves of the bud, both scale and foliage, and arrange them in regular order. Note the transition from the scale leaf to foliage leaf. Make a series of drawings to show the transition between the two types as observed.

5. Take another lilac bud and cut a transverse section of it. Examine, with the dissecting microscope, and note the arrangement (**vernation**) of the young leaves in the bud. Draw to show structure observed.

LEAF.

1. Examine a leaf of a **monocotyledonous** plant (e.g., corn). Note the medium longitudinal **midrib** and the parallel **veins**. Make a drawing of the upper surface.

2. Examine a leaf of a **dicotyledonous** plant (e.g., rose). Note: (1) the leaf stalk (**petiole**); (2) the leaf blade (**lamina**) with (3) the medium **midrib** and net-like arrangement of the **veins**. Make a drawing of the upper surface.

3. With the point of a scalpel remove a small portion of the outer covering (**epidermis**) from the under surface of a leaf. Mount in a drop of water and study with the low power. Note: (1) the epidermal cells and among them (2) the openings in the leaf (**stomata**) through which the interchange of gases takes place. Each stoma is enclosed by (3) two specialized epidermal cells (**guard cells**). Make a drawing of the epidermis to show the structures observed.

4. Examine, with the low power, a stained and mounted transverse section of a rose leaf. Select a portion of the leaf to one side of the midrib and study with high power. Note: (1) the upper layer of large, irregularly shaped cells (**upper epidermis**), below which can be seen two rows of (2) smaller cells (**palisade cells**) which are placed with their long axes at right angles to the upper epidermis. Below these is (3) an area in which the cells are not so definitely arranged (**spongy parenchyma**) and in which (4) intercellular spaces (**lacunae**) are present. The lacunae open to the exterior through the **stomata**. The palisade cells and the spongy parenchyma together comprise (5) the **chlorenchyma**. The cells of the chlorenchyma contain (6) the chlorophyll-bearing bodies (**chloroplastids**). (7) The **vascular tissue** of the veins appears, in transverse section, as more or less circular groups of irregular, lightly stained cells imbedded in the spongy parenchyma. (8) The under surface of the leaf is covered with a layer of epidermal cells (**lower epidermis**) similar to the upper surface, but more stomata are present. Make a drawing of the section to show the structures observed.

FLOWER.

1. Examine the flower provided and note that it is composed of **whorls** of modified leaves attached to a slightly differentiated portion (**receptacle**) of the stalk as follows: (1) The outermost whorl (**calyx**) consists of a number of leaf-like structures (**sepals**). The sepals form the outer covering of a flower bud. They are frequently green in color and the basal portions are often united to form a tube. (2) The next whorl (**corolla**) consists of **petals**. These may be of various colors and in some flowers are also united to form a tube. The calyx and corolla together constitute the **accessory** parts of the flower as distinguished from the **essential** parts which they enclose. These latter consist of (3) a whorl of **stamens** and (4) the central structure (**pistil**) of the flower. Make an enlarged drawing of a longitudinal section of the flower to show the relations of the parts as observed.

2. Carefully detach one of the stamens, place it on a slide and study with the dissecting microscope. Note that it consists of (1) a stalk (**filament**) and (2) head (**anther**) which contains (3) the minute **pollen grains**. Make a drawing to show the structure as observed.

3. Place some of the pollen grains on a slide and study them with the compound microscope. Draw.

4. Make a microscopic preparation of some pollen grains which have germinated and formed the pollen tube (**male gametophyte**). Study under the high power and make a drawing.

5. Remove the calyx, corolla and stamens. Examine the pistil with the dissecting microscope. Note that it consists of (1) an enlarged basal portion (**ovule case**) from which projects (2) a stalk (**style**). The style terminates in (3) an enlarged portion (**stigma**) which secretes a sticky substance to which the pollen adheres. Draw to show structures observed.

6. Cut a transverse section of the ovule case. Place on a slide and examine with the dissecting microscope. Make a drawing to show the cavities containing the immature seeds (**developed ovules**) and their attachment to the **placenta**.

EUGLENA.

1. Examine, with the low power, a drop of water which contains *Euglena*. The active specimens will be seen as green, elongated, free-swimming bodies. When an individual is not actively swimming, it shows certain characteristic squirming movements which result in marked changes (**euglenoid changes**) in the shape of the cell.

2. Make a series of outline drawings to show the successive euglenoid changes in the shape of a single individual.

3. Study the preparation with the high power. Distinguish the **anterior** and **posterior ends**. Note: (1) the **flagellum** which is attached in a depression (**gullet**) at the anterior end (careful focussing will be necessary); (2) the red pigment spot (**stigma**); (3) the **contractile vacuoles** and **reservoir**; (4) the **nucleus**.

4. The green color of *Euglena* is due to **chlorophyll**. It is present in a number of oval disks (**chloroplastids**) which are suspended in the protoplasm. Other larger bodies (**pyrenoids**) can be noted which retain the manufactured food material (**paramylum**).

5. Make a drawing about 3 inches long showing all the observed structures.

6. Occasionally, inactive individuals are found which have become almost spherical in shape and which are surrounded by a rather thick **cyst** wall. Such specimens are **encysted**. They may undergo **division** during encystment. Study any encysted specimens present in your preparation and make drawings to show structure observed.

PARAMECIUM.

1. Examine, with the low power, a drop of water which contains a number of Paramecia and a little powdered carmine. The Paramecia will be seen as light colored, rapidly moving bodies which rotate on their long axis as they swim. On account of their shape, they are frequently spoken of as "slipper animalcules." With the naked eye, the Paramecia are just barely visible as minute white specks.

2. Select a quiet animal under the low power and then study with the high power. It will probably be necessary to remove the cover glass and add a drop or two of quince seed jelly to the preparation in order to quiet them. Distinguish the **anterior** and **posterior** ends. Note: (1) the thin clear outer layer (**ectoplasm**) of the body; (2) the granular, inner layer (**endoplasm**); (3) the fine vibratile hair-like organs (**cilia**) which cover the entire body; (4) the depression (**oral groove**) which begins at the anterior end and extends obliquely backward near the middle of the body; (5) the **mouth** which is located nearly to the posterior end of the oral groove; (6) the funnel-like depression (**gullet**) which leads from the mouth down into the endoplasm; (7) the position and rhythmic appearance and disappearance of the two **contractile vacuoles** with their radiating canals.

3. Observe that the current caused by the ciliary action sweeps the carmine particles, which were placed in the drop of water, down the oral groove through the mouth opening and into the gullet, at the lower end of which they collect into **food vacuoles**. Note numerous food vacuoles in the endoplasm.

4. Focus carefully on the edges of the body and note the minute, oval, regularly arranged bodies (**trichocysts**) lying in the ectoplasm just beneath the outer surface (**pellicle**).

5. Make a drawing about 3 inches long showing the structures observed.

6. Remove the cover glass of the preparation you have been studying and add a drop or two of acetic carmine. This will kill the animals and also stain the nuclear structure (**macronucleus** and **micronucleus**). Study with the high power and add the details of nuclear structure to your drawing in paragraph 5.

7. Place a drop of the water containing Paramecia on a clean slide and kill the animals by adding a drop or two of iodine solution. Note what happens to the cilia and trichocysts. Make a drawing of a small portion of the ectoplasm showing some of the trichocysts with **stinging hairs** protruded.

8. Make a fresh preparation of the Paramecia and draw any animals you see which may be in a state of **division** or of **conjugation**.

VORTICELLA.

1. Examine, with the low power, the slide on which has been placed a drop of water containing Vorticellae and a little powdered carmine. Make a drawing of a small group.

2. Under high power note that the general shape of the organism is that of an inverted bell, usually attached by means of a long contractile **stalk**. Note **pellicle**, **ectoplasm**, and **endoplasm**. Determine how and where the particles of carmine are taken into the body. Note the **food vacuoles**.

3. Identify the following structures: (1) the **peristome**, or rounded rim about the mouth of the bell; (2) the **disk**, or elevated plate-like area, included within the peristome; (3) the **vestibule**, or depression between the disk and the peristome; (4) the **gullet**, or slender canal leading from the vestibule, through the mouth opening, toward the center of the body; (5) the **contractile vacuole**.

4. Determine what parts of the body bear cilia. Study the contractions of the stalk.

5. Make a drawing about 2 inches long showing the above structures.

6. Kill the animals with acetic carmine. Note: (1) the long U-shaped **macronucleus**; (2) the small rounded **micronucleus**; (3) that the stalk consists of a sheath continuous with the pellicle of the bell and surrounding (4) a contractile filament (**myoneme**). Add these structures to your previous drawing.

VOLVOX.

1. Place a drop of water containing Volvox on a slide. Examine, without cover glass, under the low power of the compound microscope. Each Volvox colony will be seen as a more or less transparent, hollow sphere. Note that (1) each colony is composed of a large number of minute, greenish, irregular-shaped bodies (**flagellated cells**) which are imbedded in (2) a transparent gelatinous material. (3) In many cases a number of darker colored spheres are enclosed within the walls. These are **daughter colonies** which have arisen by repeated divisions of specialized germ cells (**parthenogonidia**) which develop without fertilization. Make an enlarged drawing of a Volvox colony to show structure as given above.

2. Carefully place a cover glass on the preparation and examine with the high power. Focus on the wall of a colony at the equator, so as to get a profile view of the cells in this region. Make a careful study of a number of the cells and note that each consists of an irregular-shaped, greenish bit of cytoplasm which constitutes the cell body. Branching out from each cell body are very fine cytoplasmic strands which run through the intercellular material and connect with other cell bodies so that there is a protoplasmic continuity among the cells of the colony. Each cell possesses two flagella which project to the exterior through the intercellular material. Draw a portion of the wall of the colony giving a profile view of the cells as outlined above.

3. Focus on one of the daughter colonies, which have arisen asexually. Note the comparatively small amount of the intercellular material. Draw a portion of the wall of the colony.

4. Study a Volvox colony which is producing sexual cells. In such a colony note a **spermary** which consists of a large number of male cells (**microgametes**) grouped together to form a rather flat plate and an **ovary** of about the same size as the spermary but which contains only a single female cell (**macrogamete**). Both the spermaries and ovaries are imbedded in the wall of the colony and arise from specialized cells. Draw to show structure observed.

HYDRA.

1. Examine, with the dissecting microscope, a living Hydra in a watch glass containing water. Observe the animal when expanded and when contracted. Touch the expanded animal with a dissecting needle and observe what happens.

2. Examine the animal in the watch glass with the lowest power of the compound microscope. Note: (1) the **body**, which resembles an elastic tube attached at one end by (2) the foot (**basal disk**). (3) At the opposite end (**hypostome**) there is (4) a central opening (**mouth**) which is surrounded by (5) a circlet of **tentacles**. Note the number of tentacles your specimen possesses and compare with others at your table.

3. Focus on the cellular body wall and note that it is composed of (1) an outer layer (**ectoderm**) and (2) an inner layer (**endoderm**) which surrounds (3) a large central cavity (**enteron**) into which the mouth opens. Focus on one of the tentacles. The wall of the tentacles is composed of ectoderm and endoderm and the cavity of the enteron also continues throughout their length. Note (4) the batteries of stinging cells (**nematocysts**) imbedded in the ectoderm of the tentacles.

4. Hydra reproduces asexually by budding. Examine your specimen and see if any **buds** are present. At certain seasons of the year it also reproduces sexually and produces both male cells (**sperm**) and female cells (**ova**). The sperm are formed just below the tentacles in **testes** and the ova in **ovaries** situated below the testes.

5. Make (1) a careful drawing of an expanded animal showing in detail all parts observed above and (2) an outline drawing of a contracted animal.

6. Examine, with the low power, a permanent preparation of a transverse section through the body of a Hydra. Note: (1) the layer of ectoderm and (2) the layer of endoderm, each of which are composed of a great number of cells. These are separated by (3) a thin, non-cellular layer (**mesogloea**). These layers surround (4) the enteron. Draw the section as observed.

7. Examine the preparation with the high power and make a drawing of a small sector of the body wall to show the structure of the ectoderm and endoderm cells, and mesogloea.

OBELIA (1).

Asexual.

1. Examine, with the dissecting microscope, a specimen of *Obelia* which has been stained and mounted. Note the general form of the colony.

2. Study the preparation with the low power of the compound microscope. Note: (1) the upright stem (**hydrocaulus**) with the side branches, each of which bears either (2) a hydra-like nutritive zooid (**hydranth**) or (3) a club-shaped reproductive zooid (**gonangium**). The stem is composed of (4) an inner deeply staining portion (**coenosarc**) which is a continuation of the same material in each zooid and (5) an outer transparent skeletal sheath (**perisarc**) which encloses all parts of the colony. Note that the perisarc expands into (6) a cup-shaped structure (**hydrotheca**) surrounding each hydranth and into (7) a longer urn-shaped structure (**gonotheca**) which encloses each gonangium. Observe the constrictions in the perisarc below each zooid.

3. Study a hydranth and note: (1) the body wall which is made up of **ectoderm** and **endoderm** and is continuous with the coenosarc in the stem; (2) the central cavity (**enteron**) and (3) the **tentacles** which surround (4) the **mouth**.

4. Study a gonangium and note that the club-shaped stalk (**blastostyle**), which, as in a hydranth is continuous with the coenosarc, bears buds (**medusa buds**). Note the opening at the tip of the gonotheca through which the medusa buds escape when mature.

5. Make a half page drawing of an *Obelia* colony showing the structures observed.

OBELIA (2).

Sexual.

1. Examine, with the naked eye, a preserved medusa, of the Obelia type (e.g., *Gonionemus*). Note the gelatinous consistency of the body and the umbrella or bell shape. The upper convex surface is called the **aboral** or **exumbrella** and the lower concave surface is called the **oral** or **subumbrella**.

2. Study the specimen, with a dissecting microscope, from the oral surface. Note: (1) the **tentacles** attached near the periphery, each with an adhesive pad near the tip; (2) the perforated diaphragm (**velum**) lying below the tentacles; (3) the attached central structure (**manubrium**) made up of (4) the wide lipped **mouth** which opens into (5) the **enteron**. Radiating from the base of the manubrium are (6) the four **radial canals** with (7) the attached reproductive glands (**gonads**). The canals run to the periphery of the disk where they connect with (8) the **circular canal**. Note also (9) the sense organs, which are located around the margin of the bell at (a) the base of each tentacle and (b) between the bases of some of the tentacles.

3. Make (1) a drawing of the specimen from the oral surface and also (2) from the side to show the structures observed.

EXTERNAL ANATOMY OF THE EARTHWORM.

1. Examine a preserved earthworm and note the long, tubular body made up of a considerable number of segments, (**metameres**). Count the segments of your specimen and compare the number with others at your table. Note: (1) the mouth, which is situated at the anterior end of the body below the projecting lobe (**prostomium**) and (2) the **anus** situated at the posterior end of the body, where it can be seen as a vertical slit in the last segment; (3) the swollen region (**clitellum**) lying in the region between segments 28 and 35.

2. With one hand take hold of the anterior end of the earthworm and draw the body through the fingers of your other hand. The rough feeling is due to the presence of bristles (**setae**) which project through the body wall. Ascertain the arrangement of the setae and the number present on each segment.

3. Examine your specimen with the dissecting microscope and find the following openings: (1) openings of the **sperm ducts** in the swellings on the ventral surface of segment 15; (2) openings of the **oviducts** just lateral to the inner double row of setae in segment 14; (3) openings of the **seminal receptacles** in the grooves between segments 9 and 10, and 10 and 11, on a line with the outermost row of setae; (4) openings of the **nephridia** just lateral and anterior to the setae of the inner row on either side of each segment; (5) the openings (**dorsal pores**) on the anterior end of each segment in the median line.

4. Make (1) a drawing twice natural size of the anterior forty segments of the body from the ventral surface and (2) a drawing of the same magnification of the posterior ten segments of the body from the dorsal surface to show structures observed.

INTERNAL ANATOMY OF THE EARTHWORM.

1. Fasten the worm dorsal surface upward in a dissecting dish with a pin through the **prostomium** and another through the posterior end of the body. Cover with water. With fine scissors cut very carefully through the body wall just posterior to the **clitellum** in the median dorsal line. Extend the cut through the anterior end of the animal, being careful not to injure the intestine. Beginning at the posterior end of the cut, spread the cut edges carefully, cutting away the septa between segments, and fasten with pins. Notice the thick **body wall**, which is composed of three layers: (1) an iridescent **cuticle** on the outside; (2) a pigmented **epidermis**, and (3) a paler, thicker **muscular layer**.

2. Note the body cavity (**coelom**) with the **alimentary canal** passing through it from mouth to anus, and transverse septa dividing it into **segments**.

3. Note the **dorsal blood vessel**, generally full of coagulated blood, running along the top of the digestive tract. It gives off 5 pairs of swollen **hearts**, which pass around the digestive tract in segments 7 to 11, and unite below with the **ventral blood vessel**.

4. Dissect as little as possible to expose the alimentary canal. It consists of the following parts: (1) **mouth**; (2) **pharynx**, thick and muscular, extending back to segment 6, and attached to body wall by many slender muscles; (3) **esophagus**, thin-walled, largely obscured by the overlying reproductive organs, extending between segments 7 and 16; (4) **crop**, a thin-walled enlargement of the canal at about segment 16; (5) **gizzard**, thick-walled and muscular, at about segment 18; (6) **intestine**, extending from the gizzard to (7) **anus**.

5. Make a drawing twice natural size to show all these parts, being careful that each organ is drawn correctly with reference to the segments.

NERVOUS SYSTEM OF THE EARTHWORM.

1. Fasten your dissected specimen as before in a dissecting pan. Carefully cut through the alimentary canal posterior to the gizzard and find the **nerve cord** lying directly below in the median line. The nerve cord extends the entire length of the animal and in each segment it expands to form a **ganglion**. Two pairs of nerves arise from each ganglion and a smaller pair originate from the cord just anterior to the ganglion.

2. Carefully remove the alimentary canal anterior to the cut just made and trace the nerve cord to the anterior end of the pharynx. At this point it divides to form the nerve collar which encircles the pharynx. Note the two minute swellings (**cerebral ganglia**) on the dorsal surface of the nerve collar. These constitute the **brain** of the animal. Make an enlarged drawing of the nerve cord in the anterior third of the animal.

3. Examine, with the low power, a stained and mounted transverse section of an earthworm. Locate the section of the nerve cord in this preparation and study with the high power. Note the **outer sheath**, **ganglion cells**, **giant fibers**, **subneural blood vessel** and the **lateral nerve fibers**, if they are present in the section. Draw to show the structures observed.



TRANSVERSE SECTION OF THE EARTHWORM.

1. Examine, with the low power, a stained and mounted transverse section of the body, and make a drawing about four inches in diameter to show the relation of the following parts:

A. **Body wall**, consisting of (1) **cuticle**, a thin transparent membrane on the outside, often torn off in making the preparation; (2) **epidermis**, a cellular layer immediately beneath the cuticle; (3) **circular muscles**; (4) **longitudinal muscles**; (5) **peritoneal epithelium**, a very thin layer of cells lining the body cavity.

B. **Alimentary Canal**, appearing in transverse section as a ring surrounded by the body cavity (**coelom**). On the dorsal side is a glandular infolding (**typhlosole**) which increases the digestive surface. Surrounding the alimentary canal are the yellow cells (**chlorogogen cells**) and lining the interior are the **epithelial cells**. Muscle tissue lies between these two layers.

C. **Nerve Cord**. This has been studied in the previous exercise.

D. **Blood vessels**. Sections of the **dorsal** and the **ventral blood vessels** can usually be distinguished, lying above and below the alimentary canal.

EXTERNAL ANATOMY OF THE CRAYFISH. (1)

1. On a preserved specimen note that the body is composed of the closely united **head** and **thorax (cephalothorax)**, and **abdomen**, the latter with 7 movable joints (**segments**). The entire body is covered by a **chitinous exoskeleton**.

2. Find the following openings: (1) **mouth**, concealed by appendages; (2) **anus** on ventral surface of last abdominal segment (**telson**); (3) **excretory pores** on basal joints of antennae.

3. The cephalothorax consists of thirteen segments, more or less fused together, and covered dorsally and laterally by one piece of exoskeleton (**carapace**), prolonged anteriorly into the **rostrum**. Note the **suture** marking line of division between head and thorax. Note **eyes**, **antennae**, and **antennules**. Make a drawing of the whole animal from the left side.

4. Examine an abdominal segment which has been detached and note: (1) the dorsal arched portion (**tergum**); (2) the ventral calcified bar (**sternum**), and the non-calcified cuticle where movement takes place; (3) the downwardly projecting lateral parts (**pleura**). Examine the appendages in this segment and note: (4) the basal portion (**protopodite**) bearing (5) two jointed branches (**exopodite** and **endopodite**). Make a drawing of the segment with its appendages from the end.

EXTERNAL ANATOMY OF THE CRAYFISH (2).

1. Cut off from the left side of the animal the lateral part of the carapace, which covers the gills, and lay the animal on its side under water. Note the character of the outer gills (**branchiae**) attached to the appendages, and of the others attached to the soft cuticle joining the appendages to the body. The anterior end of the branchial cavity leads forward through a groove to the side of the mouth and in this lies a paddle-like structure (**scaphognathite**) attached to the second maxilla. Function?

2. After having carefully examined and identified the appendages of your specimen, remove them in regular order from the left side of the body, beginning with those of the abdomen. Pin them in the dissecting pan in proper order and in corresponding position. In removing them, be sure to get the whole of the appendages, including the attached gill, if present. The small appendages around the mouth must be handled very gently with fine forceps. Care must be taken not to injure the opposite side of the body.

3. Examine first the **third maxilliped**, the most posterior of the mouth appendages. Note that it, like the abdominal appendage already studied, consists of a 2-jointed basal portion (**protopodite**) to which are attached the large 5-jointed **endopodite**, the small feeler-like **exopodite**, and the **epipodite**, bearing a gill.

4. Make a series of drawings showing each of the appendages in order, all in the same relative position. Label the corresponding parts in each drawing.

LIFE HISTORY OF THE MOTH.

1. Examine a series of preparations showing the four stages in the life of an insect with complete metamorphosis, namely, **egg, larva, pupa, adult**.

2. Examine under the dissecting microscope a leaf with the attached eggs, and make a drawing.

3. Examine a larva (**caterpillar**) and distinguish the **head, thorax, and abdomen**. The head appears as one segment and bears on its side minute simple eyes (**ocelli**) and, lying on each side of the mouth, a pair of jaws (**mandibles**). The three segments behind the head constitute the thorax, each segment of which bears a pair of small legs with sharp hooks. The abdomen consists of the nine segments behind the thorax. Observe which of the abdominal segments bear appendages (**false legs**). Note the **breathing pores** on the sides of the body.

4. Note what means the animal has for protection, as indicated by spines, color pattern or other features.

5. Make a drawing of a larva from the side showing the structures observed.

6. Examine and draw the silk **cocoon** in which the larva passes the winter.

7. Carefully open the cocoon, remove the pupa and draw it from the ventral surface about twice natural size. Note head, thorax, abdomen, antenna cases, leg cases and wing cases.

8. Draw an adult moth from the dorsal surface. Note head, thorax, abdomen, fore-wings, hind-wings, legs, eyes, and antennae.

EXTERNAL ANATOMY OF THE HONEY BEE. (1)

1. Examine a freshly killed honey bee of the worker type and note that the body is divided into **head**, **thorax** and **abdomen**. Study the specimen with the dissecting microscope. On the head note the feelers (**antennae**), the large **compound eyes**, and the **mouth parts**. Observe that the thorax is composed of three segments, each of which bears a pair of jointed legs. Both the second and third segments also bear a pair of wings. Observe that the abdomen is composed of six segments, each of which is made up of a dorsal plate (**tergum**) and a ventral plate (**sternum**). At the posterior end of the abdomen is the sting, the anus and the opening for the sexual organs. Make an enlarged drawing of the bee from the left side to show the structures observed.

2. Remove the head and study the anterior surface under the dissecting microscope. Note: (1) the large compound eyes, one on either side of the head; (2) the small simple eyes (**ocelli**) in the center and almost on top of the head; (3) the pair of jointed antennae, and just below them (4) a dome-shaped structure (**clypeus**) to which is attached (5) the upper lip (**labrum**). As seen from the anterior surface the mouth parts consist of (6) a pair of **mandibles**, situated one on either side of the labrum; a pair of **maxillae**; (7) a pair of **labial palps**; (8) a long median tongue (**ligula**) and (9) a median **epipharynx** lying between the mandibles at the base of the tongue. Make an enlarged drawing of the head from the anterior surface to show the structures observed.

EXTERNAL ANATOMY OF THE HONEYBEE. (2)

1. With small forceps, remove one of the first pair of legs and study with the dissecting microscope, and also with the low power of the compound microscope. Note that the legs are composed of five joints which, beginning at the body, are named as follows: (1) **coxa**; (2) **trochanter**; (3) **femur**; (4) **tibia**, and (5) the five-jointed **tarsus**. Note: (6) the **branched hairs** for gathering pollen which are present on all the joints except the tarsus; (7) the **pollen brush** and the flattened **spine** on the tibia; (8) the **antenna comb**, which works in connection with the flattened spine on the tibia to form an antenna cleaner; (9) the **eye brush**, both on the first joint of the tarsus, and (10) the **foot**, or terminal portion of the tarsus, which consists of a fleshy pad and a pair of notched claws. Draw to show the structures observed.

2. Remove one of the second pair of legs and study as before. Observe the **spur** on the tibia, which is used to clean the wings and to pry out the pollen from the pollen basket on the third pair of legs. Draw a portion of the leg to show this structure.

3. Remove one of the third pair of legs and study as before. Note: (1) the **pollen basket**, which is a concavity on the outer surface of the tibia; (2) the **wax pincers**, which consist of a row of spines on the end of the tibia and a smooth plate on the first joint of the tarsus. These are used to remove the wax plates from the abdomen. (3) The **pollen combs** are also on the first joint of the tarsus. Draw a portion of the leg to show these structures.

4. With small forceps, remove the last two segments of the abdomen. Place them on a slide under the dissecting microscope. With a pair of needles dissect out the sting. Note the following parts: (1) a pair of **barbed darts**, which form a single long median structure; (2) a pair of **sting feelers**, one on either side of the darts, and (3) the **poison sac** with attached poison glands. Draw to show the structures observed.

POLYMORPHISM OF ANTS.

1. In a colony of ants, the individuals are of several kinds namely:

A. Queens. These are the largest individuals of the colony. The young queens possess two pairs of wings, which they lose after the nuptial flight.

B. Males. The males also possess two pairs of wings but have smaller and more slender bodies than the queens.

C. Soldiers. The soldiers are distinguished by their large heads which are provided with strong mandibles.

D. Workers. These are the smallest members of the colony. There are several kinds of workers and various types of structural modifications are present, depending upon the character of the work performed.

Both the soldiers and the workers are females with undeveloped sexual organs.

2. Make an enlarged drawing, from the dorsal surface, of each of the four types mentioned.

CLAM.

1. The shell consists of right and left **valves** which are hinged together along the dorsal surface. Lines of growth are visible and it can be noted that these radiate from the anterior end of the shell (**umbo**). Draw the external surface of the left valve.

2. Remove the left valve noting the attachments of the anterior and posterior **adductor muscles** and the **hinge**. Turn back the **mantle**, thus exposing the **mantle cavity** containing **gills**, **visceral mass**, **foot** and **inhalent** and **exhalent siphon tubes**. The inhalent siphon tube lies ventral to the exhalent.

3. Below the anterior adductor muscle, note the two pairs of **palps** between which the **mouth** may be found. Find the **anus** which opens into the exhalent siphon tube dorsal and slightly posterior to the posterior adductor muscle. Trace the intestine anteriorly from the anus to the **heart** which lies in a median dorsal position, enclosed in the **pericardial sac**. The heart consists of a single **ventricle**, which surrounds the intestine in that region, and two **auricles** lying laterally and below.

4. Make an enlarged drawing showing the internal structure of the clam as observed.



EXTERNAL ANATOMY OF THE FROG.

1. Examine a chloroformed frog, noting the general form, the division into head and trunk, and the color of the dorsal and ventral surfaces.

2. Note the large mouth, eyes, nostrils (**external nares**), ear-drums (**tympanic membranes**), the **brow-spot** between the eyes, the opening of the cloaca and the fore- and hindlimbs.

3. In the **forelimb**, identify the upper arm, forearm, and hand with wrist and digits. In the **hind limb**, identify the thigh, shank, and the foot with ankle, digits and interdigital web.

4. Make a drawing of the extended animal from the dorsal surface, showing as many of the above characters as possible.

6. Examine the eyes. Note how they close and how they are protected from injury. Make an enlarged drawing of one eye, showing eyelids, iris and pupil.

BUCCAL CAVITY AND RESPIRATORY ORGANS OF THE FROG.

1. Increase the size of the mouth opening by cutting at the corners. Pin the frog with ventral surface up and pull back the lower jaw so as to fully expose the buccal cavity. Note and draw the **upper** and **lower** jaws, with **maxillary teeth**, **vomerine teeth**, **internal nares**, **Eustachian tubes**, **gullet**, **glottis** and **tongue**.

2. Close the mouth and lay bare the **larynx** from the ventral side. Open the **lungs** up to the larynx. Note the structure of the lungs, and the relation of the glottis to the larynx. Open the larynx in the middle line and note the position of the **vocal cords**.

3. Make a drawing showing the relations of all these parts.

VISCERA OF THE FROG.

1. Pin out a chloroformed frog in a dissecting tray with a little water, ventral surface upward. Raise the skin of the ventral surface and make a longitudinal incision, through the skin only, from the **pelvis** to the **throat**. Make transverse incisions in front of the pelvis and behind the fore limbs.

2. Cut through the musculature of the body wall from the pelvis to the **sternum**. Cut through the **shoulder girdle** on each side of the sternum, being careful not to injure the heart. Make transverse incisions and pin back the flaps of muscle on each side. The body cavity is partially divided into **thorax** and **abdomen**, and is filled with the **viscera**.

3. A delicate, moist membrane (**peritoneum**) lines the whole body cavity. It is continued over each of the organs contained in the body cavity, and forms folds (**mesenteries**) by which these organs are suspended. The heart is enclosed in a delicate sac (**pericardium**), containing a small amount of **pericardial fluid**, which surrounds the heart.

4. Watch the pulsations of the heart and note the change in color of its different parts during contraction and expansion. Determine the rate of the heart beat. Place your finger tip on the heart while it is beating and note the tension of the walls.

5. **Alimentary canal**. Insert the handle of the scalpel into the **mouth**, and thence into the **esophagus** and **stomach**. Determine the dimensions of these organs. The stomach opens by the **pyloric valve** into the small intestine. The latter consists of **duodenum** and **ileum**. Posteriorly the ileum opens into the large intestine (**rectum**), which merges into the **cloaca**.

6. Note the three large lobes of the **liver**, with the **gall bladder**, from which the bile duct leads to the duodenum. Find the slender yellowish **pancreas** lying between stomach and duodenum. Its secretion enters the duodenum through the bile duct. Note the dark, rounded **spleen**, near the anterior end of the rectum.

7. Arrange all the organs so that they show to the best advantage, and make a full page drawing of all observed structures.

HEART.

1. Examine a pig's heart and note that it is conical in form, with a broad base and a narrow apex. Place it with the apex pointing towards you and identify the anterior, posterior, dorsal and ventral aspects.

2. Note the following external features: (1) the **left ventricle**, with very thick muscular walls; (2) the **right ventricle**, with thinner walls lying beside the right ventricle; (3) the **left auricle**, and (4) the **right auricle**, both lying anterior to the ventricles. The auricles have much thinner walls than the ventricles, and are each provided with (5) an ear-like **appendix**.

3. Explore the cavity of the left auricle, noting (1) the openings of the **pulmonary veins**, and (2) the opening into the left ventricle.

4. Explore the cavity of the left ventricle, noting (1) the very heavy muscular walls; (2) the **mitral valve**, guarding the opening from the auricle, the edges of which are attached to (3) elevations (**papillary muscles**) of the muscular walls of the ventricle by a number of (4) fine tendinous cords (**chordae tendineae**). Feel with your finger and find (5) the opening into the **aorta**. Study the aorta, noting (6) its thick heavy walls; (7) the **semilunar valves**, and (8) the opening of the **coronary artery** just beyond the valves.

5. Explore the cavity of the right auricle, noting (1) the large opening from the **venae cavae**; (2) the small opening of the **coronary vein** just posterior to the former, and (3) the opening into the right ventricle.

6. Explore the cavity of the right ventricle, noting (1) the thickness of the walls as compared with the left ventricle; (2) the **tricuspid valve**, which shows the same structure as the mitral valve. Find the opening into (3) the **pulmonary artery**, which contains (4) semilunar valves the same as the aorta.

7. Make a drawing of the heart from the left side, showing as many as possible of the observed structures.

8. Study, under the microscope, the circulation of the blood in the **capillaries** of the tongue of the frog, or in the web between the toes. Note the differences in the rate and manner of the flow of the blood in different vessels.

UROGENITAL SYSTEM OF THE FROG.

1. Carefully remove the heart, lungs, liver and digestive tract from the specimen supplied. In removing the digestive tract, cut through the esophagus anterior to the stomach and through the small intestine just anterior to the rectum. Carefully split the pelvis in the median plane from the ventral side and lay bare the **cloaca**. Note the thin-walled, bilobed **bladder** attached to the ventral surface of the cloaca.

2. **Female frog.** In the spring the right and left ovaries become greatly distended and fill a large portion of the body cavity. Separate the ovaries and push them to either side so that the other organs may be seen to advantage. Note: (1) a pair of reddish, flattened, oval-shaped **kidneys**; (2) a pair of elongated, orange-colored **adrenal bodies**, one lying on the ventral surface of each kidney; (3) a pair of yellowish **fat bodies** with long finger-like processes; (4) a pair of long, coiled **oviducts** which open anteriorly into the body cavity near the base of each lung. Posteriorly, before opening into the cloaca, each of the oviducts becomes differentiated into (5) a thin-walled **uterus**. Examine the outer margin of the kidneys and find (6) the **ureters**, which can be traced posteriorly to their openings into the cloaca. Note also the blood vessels attached to the kidneys. Make an enlarged drawing to show the structures observed.

3. **Male frog.** Locate and examine the following parts of the male urogenital system: (1) a pair of reddish, flattened, oval-shaped **kidneys**; (2) a pair of white **testes** attached to the kidneys by a number of fine ducts (**vasa efferentia**); (3) a pair of elongated, orange-colored **adrenal bodies**, one lying on the ventral surface of each kidney; (4) a pair of yellowish **fat bodies** with long finger-like processes; (5) in many specimens a pair of much-coiled **rudimentary oviducts** are to be found situated laterally to the kidneys. Examine the outer margin of the kidneys and find (6) the **urogenital canals**, which can be traced posteriorly to their openings in the cloaca. Note also the blood vessels attached to the kidneys. Make an enlarged drawing to show the structures observed.

KIDNEY.

1. Examine a longitudinal section of a pig's kidney and note: (1) the outer **cortical portion**, which contains the **Malpighian bodies**; (2) the inner **medullary portion**, which contains the **uriniferous tubules**; (3) the **pelvis**, which opens into the **ureter**. The medullary portion consists of a number of conical parts (**pyramids of Malpighi**), and these are separated from each other by prolongations of the cortical portion of the kidney. The pyramids of Malpighi each end in a **papilla**, which projects into the pelvis. Make a drawing to show the structures observed.

2. Examine, with the low power, a prepared microscopic section of a pig's kidney and make a drawing to show as many as possible of the structural details given in the preceding paragraph.

ANATOMY OF THE EYE.

1. Examine your own eye with the mirror of a dissecting microscope. Make a drawing showing the **eyelids**, **cornea**, **iris** and **pupil**.

2. Examine the eye of a sheep. Note: (1) the shape; (2) the character of the outer protective covering (**sclerotic coat**); (3) the attachment of the muscles and (4) the optic nerve. Make a drawing of the eye from the side.

3. On the half of the eye provided find the following layers: (1) the **sclera**, a thick, white protective layer of connective tissue which you have already observed in paragraph 2; (2) the **choroid**, or vascular layer, a more delicate, deeply pigmented layer which contains numerous blood vessels; (3) the **retina**, or sensory layer. It is the innermost layer and is directly continuous with the optic nerve. Observe that in front the sclera is transparent and forms the **cornea**, and that the choroid forms the **iris**. Lying just back of the iris is the **lens**.

4. Note the chambers of the eye: (1) the anterior chamber between the cornea and the iris, and (2) the posterior chamber, between the iris and the lens. These chambers communicate through the pupil and are filled with a fluid (**aqueous humor**). The large chamber behind the lens (**vitreous chamber**), in which the retina lies, is filled with a jelly-like substance (**vitreous humor**).

5. Make a drawing about three inches in diameter showing the observed structures in the section of the eye.

SPINAL NERVES OF THE FROG.

1. Examine the dorsal wall of the body cavity of a preserved frog, from which the viscera has been removed, and identify the paired **spinal nerves**, which may be seen as whitish cords running out from either side of the median spinal column. There are ten pairs of these in the adult frog. They arise in the spinal cord and emerge from between the vertebrae through the light-colored **calcareous bodies**.

2. Beginning at the anterior end, identify and trace the ten pairs of spinal nerves as follows:

I. A small pair which emerge from between the first and second vertebrae just anterior to the fore limbs, give off a small branch to the second nerve and continue laterally into the muscles.

II. A large pair which supply the fore limbs after having received branches from the first and third pairs. This union of the first, second and third nerves is known as the **brachial plexus**.

III. A small pair, which, after giving off a branch to the second pair, can be traced laterally into the muscles.

IV, V and VI are small pairs, which can be traced into the muscles of the body wall.

VII, VIII and IX are larger pairs which run almost directly posteriorly and anastomose to form the **sciatic plexus**, from which arises the large **sciatic nerve**. By careful dissection follow the sciatic nerve from the plexus down through the leg and into the foot, noting the various branches which are given off. Note also a branch of the seventh nerve, which is given off anterior to the sciatic plexus.

X. A small pair which emerge from the openings near the anterior end of the **urostyle** and supply chiefly the urogenital organs.

3. Make a drawing to show the location and course of the spinal nerves.

CENTRAL NERVOUS SYSTEM OF THE FROG (1).

1. Slice off the roof of the skull in the eye region with a sharp, stout scalpel and expose the brain, using great care not to cut too deep. Extend the opening anteriorly to the nasal cavity and posteriorly to the end of the skull. With scissors remove the arches of the vertebrae and lay bare the spinal cord and the origin of the spinal nerves.

2. The brain and spinal cord are covered by a thin pigmented membrane, the **pia mater**. In opening the neural canal a thicker membrane, the **dura mater**, has been cut through. The space between the two is filled with a fluid—the **cerebro-spinal fluid**.

3. Note that the brain is divided into three regions, the **forebrain**, **midbrain** and **hindbrain**. The forebrain consists of the paired **cerebral hemispheres**, and in front of these the **olfactory lobes** from which the **olfactory nerves** may be seen extending to the nose. Posterior to the hemispheres is an unpaired portion, the **diencephalon**, bearing the **pineal gland**. The midbrain as seen from the dorsal surface consists of a pair of **optic lobes**. The hindbrain consists of the **cerebellum**, a small transverse ridge posterior to the optic lobes, and of the **medulla oblongata**, which merges into the spinal cord. In the medulla is a large triangular depression, the **fourth ventricle**.

4. In the spinal cord note two enlargements, and the terminal thread (**filum terminale**) in which it ends posteriorly. Carefully lift the posterior part of the spinal cord and see that each spinal nerve arises by a dorsal and a ventral root. Situated on the dorsal root where it emerges from between the vertebrae is a yellow nodule—the **spinal ganglion**.

5. Make a drawing at least twice natural size to show the dorsal surface of the brain and spinal cord as noted above.

CENTRAL NERVOUS SYSTEM OF THE FROG (2).

1. Carefully remove the entire brain and spinal cord from your specimen. In order to do this it will be necessary to cut the connecting cranial and spinal nerves. Begin at the anterior end and cut the olfactory nerves first. Then carefully raise the anterior end of the brain, note the large optic nerves and cut them. Continue posteriorly in this manner, and when the brain and spinal cord is free, remove it and place in a small dish of water.

2. Study the ventral surface of the brain as you have previously done the dorsal surface, locating the forebrain, midbrain and hindbrain. Note: (1) the crossing of the optic nerves (**optic chiasma**); (2) the **infundibulum**, and (3) the **pituitary body**.

SHEEP'S BRAIN.

3. Examine a median sagittal section of a sheep's brain and identify the following structures: (1) the forebrain with **cerebrum**, **corpus callosum**, **olfactory lobe**, **optic thalamus**, **pineal gland** and **pituitary body**; (2) the midbrain with **corpora quadrigemina**, **optic nerve** and **crura cerebri**; (3) the hindbrain with **cerebellum**, **pons varolii** and **medulla oblongata** merging into the **spinal cord**. Draw to show the observed structures.

AXIAL SKELETON.

1. Draw a dog's **skull** from the side, showing the outlines of the separate bones and note the **cranium** enclosing the brain, and the **facial bones**. Locate the **olfactory**, **optic**, and **auditory sense capsules** and note how the sense organs are protected from external injury. Note the various **foramina** for the exit of nerves from the cranium, especially the **auditory meatus** and the **foramen magnum** at the base of the skull. Note also the **condyles** by which the skull articulates with the vertebral column and the **concavity** by which the lower jaw articulates with the skull. Identify the following bones: **occipitals**, **parietal**, **frontal**, **nasal**, **premaxillary**, **maxillary**, **sphenoids**, **vomer**, **tympanic bulla**, **temporal**, **zygomatic process of temporal**, and **malar**.

2. Draw the lower jaw (**mandible**) from the side in its proper position with respect to the skull. Note the similarity and relation of the **teeth** of both jaws, and their adaptation for different purposes. They are differentiated into **incisors**, **canines**, **premolars**, and **molars**.

3. Draw an end, or a side, view of a **lumbar vertebra**, identifying **spinous process**, **anterior and posterior articular processes**, **transverse process** and **centrum**.

APPENDICULAR SKELETON.

1. Determine from the mounted skeleton, the differences between the fore and hind limbs, of the dog.

2. Make a drawing of a **forelimb**, and note the following parts: the **scapula**, or shoulder blade, with **spinous process**; **humerus**; **radius** and **ulna**; **carpals**, forming the wrist; **metacarpals**, forming the hand; and **phalanges**, in the fingers.

3. Make a drawing of a **hindlimb**, noting the following: the **pelvis**, made up of the **ilium** situated dorsally, the **pubis** situated ventrally, and the **ischium** situated posteriorly, all of which are fused together; the **femur**; **tibia**; **fibula**; **tarsals**, forming the ankle; **metatarsals** forming the foot, and **phalanges**, in the toes.

4. Study for comparison the limb bones of man, bat, and bird. Note the homology of the principal bones, and the modification, consolidation, or suppression, of parts to adapt the limb to its functional requirements.

EPITHELIAL TISSUE.

1. **Squamous Epithelium.** Mount a stained piece of the shed superficial layer from the outer surface of the skin of a frog and examine with the high power. Note that it is a mosaic made up of flattened epithelial cells (**squamous epithelium**). Draw a few of the cells with their nuclei.

2. **Stratified Epithelium.** Examine, with the high power, a stained and mounted transverse section of frog skin. Select a portion of the upper surface which shows the layers of epithelial cells (**stratified epithelium**). Draw to show the general arrangement and shape of the cells in the various layers. Note the glands which are present.

3. **Columnar Epithelium.** Examine, with the high power, a stained and mounted transverse section of frog intestine. Select a portion of the inner lining of the intestine which shows the elongated epithelial cells (**columnar epithelium**). Note that there are two kinds of these: (1) the absorptive cells, and (2) the secretive cells (**goblet cells**). The latter may be distinguished by the presence of a large oval vacuole. Note the eccentric position of the nuclei. Draw to show the general arrangement and structure of these two type of epithelial cells.

4. **Ciliated Epithelium.** Secure a small bit of fresh mucous membrane from the roof of the frog's mouth. Place it on a slide in a drop of normal salt solution and tear apart with dissecting needles. Cover and examine with high power. Note the ciliated epithelial cells. Draw. Remove cover glass, stain and study the preparation again with the high power. Add to previous drawing any additional details observed.

CONNECTIVE TISSUE.

1. **Fibrous Connective Tissue.** Examine, with the high power, a prepared transverse section of frog skin. Note that: (1) the outer portion of the skin (**epidermis**) is made up of several layers of stratified epithelial cells, which you have previously studied; (2) the inner portion of the skin (**dermis**) is divided into a comparatively loose layer of connective tissue (**stratum spongiosum**) lying next to the epithelial cells. The stratum spongiosum is made up of connective tissue fibers and imbedded in it are numerous glands, blood vessels, and lymph spaces. The other portion of the dermis consists of (3) a layer of very dense connective tissue (**stratum compactum**), in which the bundles of wavy connective tissue fibers run, in general, parallel to the surface of the skin. At intervals this layer is crossed by vertical strands which extend through the stratum spongiosum to the epidermis. These strands are made up of connective tissue fibers and also, in some cases, muscle fibers, nerves and blood vessels. Draw a portion of the section to show the structure as observed.

2. **Cartilage.** Examine, with the high power, a stained and mounted piece of hyaline cartilage from the sternum of a frog. Note: (1) the transparent, homogeneous, intercellular substance (**matrix**), which contains (2) numerous spaces (**lacunae**), each of which contains (3) one or more nucleated **cartilage cells**. Note also, in various regions of the preparation, that the lacunae containing the cartilage cells show a tendency to group together. Draw a portion of the section to show structure observed.

MUSCULAR TISSUE.

1. **Unstriated Muscle.** Place a small piece of the fresh bladder of a frog in a drop of normal salt solution on a slide. Tear apart with dissecting needles. Stain with acetic carmine. Mount and examine with high power. Note the layers of epithelium and the bands of unstriated muscle tissue. Study the latter carefully and observe that it is composed of elongated, spindle-shaped muscle cells, each containing a nucleus. Draw to show structure observed.

2. Examine, with the high power, a prepared transverse section of frog intestine. Focus on the outer edge and note: (1) a thin covering layer (**peritoneum**); (2) the unstriated muscle tissue consisting of an outer layer of longitudinal muscle fibers and an inner layer of circular muscle fibers. Draw a portion of the section to show the muscle tissue.

3. **Striated Muscle.** Place a small piece of fresh muscle from a frog's leg in a drop of normal salt solution on a slide. Tear it apart with dissecting needles. Stain with acetic carmine. Mount and examine with low power. Note that the muscle tissue consists of long, cylindrical fibers bound together by connective tissue. Study with high power and note: (1) the thin cell walls (**sarcolemma**); (2) the muscle tissue (**sarcoplasm**), showing (3) distinct **cross striations** and (4) less distinct **longitudinal striations**. Observe (5) the numerous nuclei imbedded in the sarcoplasm. Draw to show structure observed.

4. Examine, with high power, a prepared section of striated muscle tissue, the blood vessels of which have been injected with colored gelatine. Note the intimate relation existing between the capillaries and the muscle fibers. Draw to show structure observed.

NERVE TISSUE.

1. Examine, with the low power, a prepared transverse section of the spinal cord of a frog. Note: (1) the outer covering (**pia mater**); (2) the **dorsal fissure**, and (3) the **ventral fissure**—the former being more shallow; (4) the **white matter**, largely composed of nerve fibers and supporting tissue; (5) the **gray matter**, containing nerve cells; (6) the **central canal** lined with epithelium and, if present, (7) the dorsal and ventral roots of a spinal nerve. Make a drawing to show the structure as observed.

2. Focus directly on the large motor nerve cells in the ventral portion of the gray matter and study them with the high power. Note their general branched form and nuclei. Draw one of the cells showing all details of structure.

3. Tear apart, on a slide in normal salt solution, a small piece of a fresh nerve from a frog. Cover and examine with the microscope. Note that the nerve is made up of a large number of fibers, each of which consists of (1) a delicate external membrane (**neurilemma**); (2) a thick layer of fatty material (**medullary sheath**), and (3) the **axis cylinder (axon)**. At intervals along the fibers, constrictions (**Nodes of Ranvier**) occur. At such points, there is a break in the medullary sheath, but the neurilemma and axis cylinder are continuous. Careful observation will show nuclei lying just under the neurilemma. Draw to show the structure as observed.

OÖGENESIS.

1. Examine a fresh pig ovary. Note: (1) the numerous **Graafian follicles** in various stages of development—the more mature ones are larger and more transparent; (2) the masses of yellowish tissue (**corpora lutea**), which indicate the positions of previous Graafian follicles from which the eggs (**ova**) have been discharged. Make an enlarged drawing to show the structure as observed.

2. Examine, with the low power, a prepared section of a mouse ovary. Note the general structure, consisting of Graafian follicles, in various stages of development, surrounded by connective tissue. Note the immature ova in a number of the follicles. Draw to show the structure observed.

3. Select one of the more mature follicles which contains an ovum with nucleus. Study with high power and make a drawing of the entire follicle, showing the follicle cells, and the ovum with cell wall, cytoplasm and nucleus.

SPERMATOGENESIS.

1. Examine, with low and high power, a section of mouse testis. Draw a portion of the testis to show the **seminiferous tubules** containing the **germinal cells**, and the **epididymis**.

2. Examine, with the high power, a portion of one of the seminiferous tubules. Make a drawing to show the arrangement and structure of the following types of cells: **spermatogonia**, **spermatocytes**, **spermatids** and mature **spermatozoa**.

3. Under high power make a drawing about one inch in diameter of a single large **spermatocyte** which shows: **cell membrane**, **cytoplasm**, **nuclear membrane**, and **chromatin**. The latter in many cases is arranged in the form of **chromosomes**.

4. With high power, examine and draw one of the tubules of the **epididymis**. Note that these tubules are filled with mature **spermatozoa**.

CELL DIVISION (MITOSIS).

1. Examine, with the low power, a prepared, transverse section of the parasitic worm, *Ascaris megalocephala*. Note the uterine wall and the enclosed, thick-shelled ova. Draw the entire section in outline and then fill in a small sector with careful detail.

2. Study the preparation with the high power, identify the following stages and make a drawing (two inches in diameter) of each stage. Label in each stage where present: **egg shell**, **cytoplasm**, **attraction spheres** with **centrosomes** and **asters**, **chromatin** or **chromosomes** and **spindle fibers**.

I. **Fusion of the male and female pronuclei.**

II. **Early prophase** with the chromatin in the form of a long thread (**spireme**) and the centrosomes at opposite poles of the nucleus.

III. **Late prophase** with definite chromosomes, the nuclear membrane broken down and the spindle well developed.

IV. **Metaphase**, with the chromosomes divided; or **Anaphase**, with the chromosomes moving along the spindle fibers to the centrosomes.

V. **Telophase**, with the spindle breaking down and the single cell constricting to form two cells.

DEVELOPMENT OF THE FROG (1).

1. Place an unsegmented frog's egg in a watch glass containing water. Examine it both with the dissecting microscope and with the low power of the compound microscope. Note: (1) the transparent jelly enclosing the egg; (2) that the egg is composed of a dark-colored portion (**animal pole**), which tends to lie uppermost in the water, and (3) a lighter-colored portion (**vegetal pole**). Make a drawing of the egg from the side, one inch in diameter, so as to show both poles and the jelly.

2. Examine, as before, the following segmentation stages: 2-4 cells, 8 cells, 20-30 cells, and **blastula**. Note the direction of the cleavage planes and comparative size of the cells in the animal and vegetal poles. Draw each stage from the side as above, omitting the jelly.

3. Examine, as before, an egg in the **gastrula** stage which shows the growth of the dark cells over the light cells. As this process of gastrulation continues, the circular area (**blastopore**) becomes smaller, and finally, in a later stage, only a small portion of the white material is visible, which is known as the **yolk plug**. Draw the gastrula from the vegetal pole.



DEVELOPMENT OF THE FROG (2).

4. Examine, as before, a later stage of frog embryo, in which the body of the animal has begun to elongate. Note: (1) the slit-like blastopore which marks the posterior end of the embryo, and (2) the dorsal longitudinal groove (**neural groove**), which indicates the position of the future central nervous system. Draw the embryo from the posterior end.

5. Examine, as before, (1) an embryo in which the head and tail have just become differentiated; (2) an embryo with well-developed external gills; (3) a fully formed, free swimming tadpole in which the external gills have become covered by the **operculum**. Note the small opening (**spiracle**) on the left side of the animal in the gill region; (4) an embryo in an early stage of metamorphosis showing a single small pair of hind legs; (5) an embryo showing a late stage of metamorphosis in which both pairs of legs are present and the tail is in process of absorption. Draw each of these embryos from the left side. Label in each stage, where developed; nose, eye, mouth, sucker, gills, operculum, muscle plates, blastopore or anus, tail fin.



DEVELOPMENT OF THE CHICK.

1. Place an egg, which has been incubated three days, in a finger bowl of warm (about 38° C) normal salt solution, with the blunt end pointing to your right. Hold the egg firmly with one hand, and with the other carefully insert the point of the scissors in the center of the blunt end. While holding the egg in the same position continue the cut entirely around the equator of the egg and then lift off the upper portion of the shell, leaving the rest of the egg with the embryo immersed in the salt solution.

2. Examine, with the dissecting microscope, the translucent embryo lying on the yolk at the center of the **vascular area**, noting how it is placed with reference to the axis of the egg. Note the beating **heart**, the **vitelline arteries** and **veins**, which pass out to the side from the middle of the embryo and the anterior **vitelline vein**, which runs in under the head of the embryo. Determine the **pulse rate**. Make a drawing of the egg with the embryo to show the general arrangement.

3. Carefully make a circular cut with small scissors through the yolk membrane just outside the limit of the vascular area, and gently float the embryo into a watch glass filled with warm salt solution. Examine the embryo with the dissecting microscope and with the low power of the compound microscope. If the heart is still beating note the movement of the blood in the vessels; if it is not, the salt solution has become too cold and must be replaced.

4. In the head notice the **forebrain**, **midbrain**, and **hind-brain**; the **nose**, **eye** and **ear**; the **gill arches** and **clefts**. Note the **heart** and the large **blood vessels** leading to it. In the trunk note the **muscle plates** and the **spinal cord**.

5. Examine a stained and mounted preparation of a similar embryo with the dissecting microscope or with the low power of the compound microscope, and make a full page drawing to show the observed structures.



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